

# **INDOOR AIR QUALITY ASSESSMENT**

**Salem City Hall  
93 Washington Street  
Salem, MA 01970**



Prepared by:  
Massachusetts Department of Public Health  
Center for Environmental Health  
Bureau of Environmental Health Assessment  
Emergency Response/Indoor Air Quality Program  
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## **Background/Introduction**

At the request of Joanne Scott, Health Agent for the Salem Health Department (SHD), the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Salem City Hall (SCH), Salem, Massachusetts. The request was prompted by general indoor air quality symptoms by occupants in the Collectors Office. On November 23, 2004, a visit to conduct an indoor air quality assessment was made by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by David Greenbaum, Sanitarian, SHD.

The SCH is a three-story, red brick building constructed in 1837. The building has undergone interior renovations over the years. The original single-paned sash windows are openable throughout the building. The building contains city offices and public meeting rooms. The basement of the building is unoccupied, but used for storage.

## **Methods**

BEHA staff conducted air tests for carbon dioxide, temperature and relative humidity with the TSI, Q-Trak, IAQ Monitor, Model 8551. BEHA staff also performed visual inspection of building materials for water damage and/or microbial growth.

## **Results**

The SCH has an employee population of approximately 30 and can be visited by up to 500 individuals daily. The tests were taken during normal operations. Test results appear in Table 1.

## **Discussion**

### **Ventilation**

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in five of twenty-three areas surveyed, indicating adequate ventilation in the majority of areas of the building. However, it is important to note that a number of areas were unoccupied or sparsely populated at the time of the assessment. Low room occupancy can contribute to reduced carbon dioxide levels.

The building is not equipped with a modern mechanical ventilation system but relies on openable windows for air circulation. In a number of cases, openable windows in offices have been eliminated with the permanent installation of window-mounted air conditioners. Without a means for air exchange via windows or a mechanical supply and exhaust system, normally occurring indoor environmental pollutants (e.g., ozone from photocopiers, odors from cleaning products) can build up and lead to indoor air quality/comfort complaints.

Please note, all air conditioners examined were equipped with a “fan only”, “fresh air” and/or an “exhaust open” setting (Picture 1). Operating air conditioning units in such

modes can provide air circulation, since unconditioned outside air is delivered (i.e., air provided by unit equals that of outside temperature).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat

irritation, lethargy and headaches. For more information concerning carbon dioxide, please see [Appendix A](#).

Temperature readings ranged from 71° F to 75° F, which were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 30 to 34 percent, which was below the BEHA recommended comfort range in all areas surveyed. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### **Microbial/Moisture Concerns**

Water damaged wall plaster, peeling paint and efflorescence were observed on ceilings and walls in a number of areas in the buildings (Table 1/Pictures 2 and 3). Water damage is most likely the result of water penetration through the building envelope. The majority of water damage was reportedly from historic leaks. Occupants in the Financial Office reported active leaks, primarily at the top corner of the window frame and along the ceiling exterior wall junction, during periods of wind-driven rain (Picture 4).

Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar and brick, water-soluble compounds in mortar and brick dissolve, creating a solution. As the solution moves to the surface of the mortar or brick, the water evaporates, leaving behind white, powdery mineral deposits.

Several areas also had water-damaged ceiling tiles and/or curtains (Picture 5). Water-damaged porous materials can provide a medium for mold growth and should be replaced after a moisture source is discovered and repaired.

The gutter/downspout system on the east exterior wall was damaged and sections of the exterior wall were saturated with moisture (Picture 6). A section of the gutter/downspout system on the west corner of the building was missing (Picture 7). Some areas of exterior brick had missing/damaged mortar (Picture 8). Excessive exposure of exterior brickwork to water can result in structural damage. During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork. Over time, these conditions can undermine the integrity of the building envelope and provide a means for water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

A number of areas had water coolers installed over carpeting (Picture 9). Water spillage or overflow of cooler catch basins can result in the wetting of the carpet. In addition, some of the coolers had residue/build-up in the reservoirs. These reservoirs are designed to catch excess water during operation and should be emptied/cleaned regularly to prevent microbial and/or bacterial growth.

The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials (carpeting, ceiling tiles, etc.) be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

### **Other Concerns**

Several other conditions that can potentially affect indoor air quality were identified during the assessment. As discussed, a number of areas contained window-mounted air conditioners. This equipment is typically equipped with filters, which should be cleaned or changed per the manufacturer's instructions to avoid the build up and re-aerosolization of dirt, dust and particulate matter.

A number of areas contained photocopiers. Volatile organic compounds (VOCs) and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. VOCs are materials, which evaporate readily and can be irritating to eyes, nose and throat. Ozone is a respiratory irritant (Schmidt Etkin, 1992). Photocopiers should be located near local exhaust ventilation or in well-ventilated areas (e.g., hallways) to remove/reduce excess heat and odors. No mechanical local exhaust ventilation exists in the building.

Also of note was the amount of materials stored inside offices. In areas throughout the building, items were observed on windowsills, tabletops, counters,

bookcases and desks. The large number of items stored provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Several areas had cloth curtains that were water damaged, stained or had accumulated dust. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Finally, several areas around the building had open utility holes for pipes, cables, etc. (Picture 10). Open utility holes can provide a means for odors and/or particulates to migrate between rooms and floors.

## **Conclusions/Recommendations**

In view of the findings at the time of the visit, the following recommendations are made:

1. Open windows to temper room temperature and provide fresh air. As discussed, this building was designed to use windows (in combination with radiators) to provide fresh air and heat. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
2. Consider supplementing fresh air by operating window-mounted air conditioners in the "fan only" "fresh air" mode, which introduces outside air by mechanical means.
3. Consider consulting with an architect, masonry firm or general contractor regarding the integrity of the building envelope, primarily concerning water penetration through exterior walls. Ensure all leaks are repaired. Once leaks are repaired, repair water-damaged plaster/paint and examine the feasibility of repointing brickwork.
4. Repair/replace missing/damaged sections of gutter/downspout system.

5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g. throat and sinus irritations).
6. Clean/change filters for air-conditioning units as per the manufactures instructions or more frequently if needed. Clean/vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates.
7. Relocate or consider reducing the amount of materials stored in common areas to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
8. Launder and/or vacuum curtains periodically to prevent dust accumulation. Replace stained/water damaged curtains.
9. Seal holes in the floors, walls and ceilings for pipes and cables to prevent the egress of odors and particulates between rooms and floors.
10. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website:  
<http://www.state.ma.us/dph/beha/iaq/iaqhoFtme.htm>.

## References

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**Picture 1**



**Close up of Air Conditioning Control Panel, Note “Fan Only” and “Fresh Air” Controls**

**Picture 2**



**Efflorescence (i.e., Mineral Deposits) on Attic Office Wall**

**Picture 3**



**Water Damaged Ceiling Plaster and Peeling Paint**

**Picture 4**



**Water Damaged Area of Active Leak Reported in Elections & Registration Office**

**Picture 5**



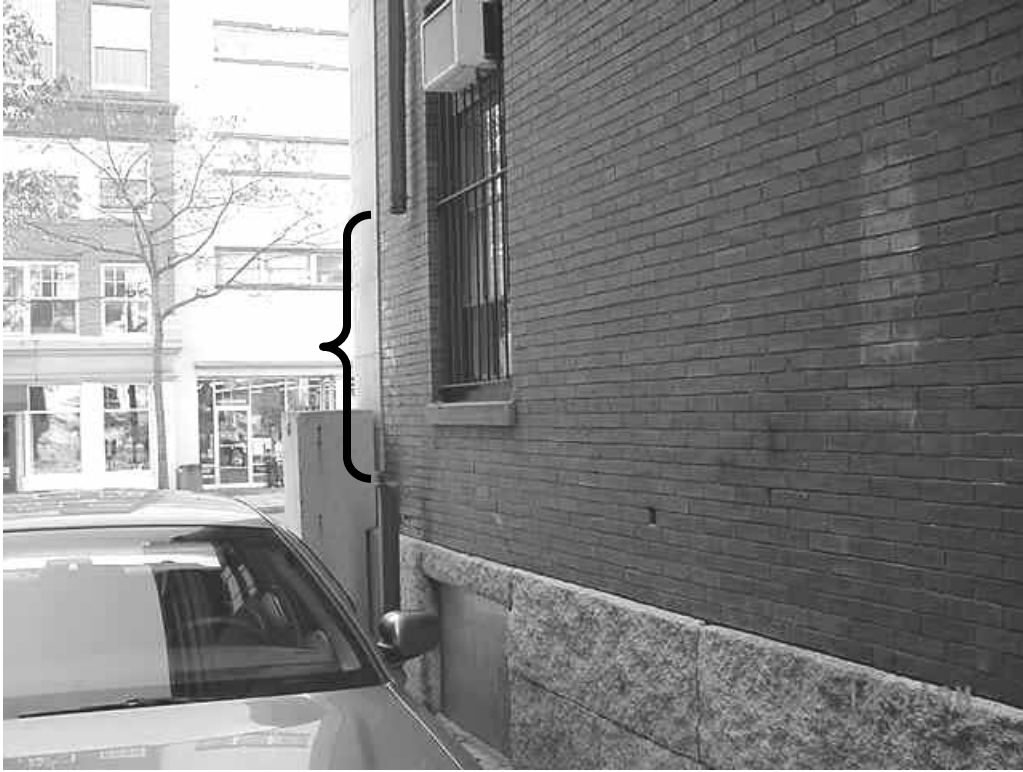
**Stained/Water Damaged Curtains in First Floor Break Room Collectors Office**

**Picture 6**



**Damaged (Split-Open) Downspout on East Side of Building**

**Picture 7**



**Missing Section of Downspout on West Corner of Building**

**Picture 8**



**Missing/Damaged Mortar around Exterior Brick**

**Picture 9**



**Water Cooler on Carpeting**

**Picture 10**



**Open Utility Holes around Pipes**

TABLE 1

## Indoor Air Test Results – Salem City Hall

November 23, 2004

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	388	43	24					Weather conditions: sunny, clear skies, variable winds, traffic moderate to heavy
4 <sup>th</sup> Floor Break Room	705	75	33	0	Y	N	N	WD/efflorescence on wall plaster, window AC-filter dusty
4 <sup>th</sup> Floor Vacant Office	710	74	32	0	N	N	N	Window unopenable due to installation of AC
Finance Office	692	75	31	0	Y	N	N	Window AC, air purifier
Deputy Auditor	758	75	31	1	Y	N	N	Window AC-dusty grill, air purifier on floor, plants
Mayor's Office	841	71	30	0	Y	N	N	Multiple meetings held during morning, water damaged ceiling plaster/peeling paint, window AC
Mayor's Reception	771	71	30	2	Y	N	N	Photocopier, Window AC
Chief of Staff	994	71	33	1	Y	N	N	
Council Chamber	650	71	32	0	Y	N	N	Window AC, WD ceiling plaster, peeling paint
City Council	615	71	32	0	Y	N	N	WD/peeling paint ceiling

\* ppm = parts per million parts of air  
WD = water damage, CT = ceiling tile

## Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred  
600 - 800 ppm = acceptable  
> 800 ppm = indicative of ventilation problems  
Temperature - 70 - 78 °F  
Relative Humidity - 40 - 60%

Table 1-1

TABLE 1

## Indoor Air Test Results – Salem City Hall

November 23, 2004

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Finance	713	73	32	2	Y	N	N	WD/peeling paint around window and along ceiling/wall, periodic leaks reported during wind-driven/heavy rains, Water cooler on carpet, Window ACs
Human Resources Benefits Office	724	73	32	1	Y	N	N	Window AC-dusty/cobwebs, Plants
Human Resources	710	74	32	2	Y	N	N	Window AC
Human Resources Director	751	75	32	1	Y	N	N	Window AC
Elections and Registrations	645	73	30	4	Y	N	N	WD plaster, peeling paint along wall/ceiling, Wall-mounted AC
Break Room					Y	N	N	WD Ceiling plaster/peeling paint, WD curtains, utility holes-ceiling
City Clerk	723	73	31	2	Y	N	N	Window AC
City Clerk Copy Room	682	73	32	0	Y	N	N	Photocopier, no local exhaust ventilation, 3 CTs, dislodged ceiling tile

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Temperature - 70 - 78 °F  
Relative Humidity - 40 - 60%

Table 1-2

TABLE 1

## Indoor Air Test Results – Salem City Hall

November 23, 2004

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
City Council Room 1	735	72	33	1	Y	N	N	Window AC, photocopier-no local exhaust
Hearing Office	710	72	31	1	Y	N	N	Window AC
Switchboard	784	73	32	2	Y	N	N	Window AC
Collectors Office Main	840	73	32	2	Y	N	N	2 window ACs, curtains
Collection Desk	798	74	33	1	Y	N	N	Humidifier
Assessors Office	841	73	33	2	Y	N	N	Humidifier, AC, water cooler on carpet
Assessors Inner Office	904	75	34	3	Y	N	N	
Perimeter Notes								Missing/damaged mortar around exterior brick, damaged downspout-East side of building wall, missing section of downspout West side of building

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 WD = water damage, CT = ceiling tile

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                           > 800 ppm = indicative of ventilation problems  
 Temperature - 70 - 78 °F  
 Relative Humidity - 40 - 60%

Table 1-3